BASIC TRAINING PROGRAM

in

LIDAR SPEED MEASUREMENT

STUDENT MANUAL

U.S. Department of Transportation
National Highway Traffic Safety Administration

National Highway Traffic Safety Administration

Produced in cooperation with
The International Association of Directors of Law Enforcement Standards and Training

SPEED SHATTERS LIFE

NHTSA
People Saving People

Important Note To Users

The Basic Training Program in Lidar Speed Measurement was developed as a result of requests from law enforcement administrators, agencies, and national organizations. This course is the result of a cooperative effort between the National Highway Traffic Safety Administration (NHTSA) and the International Association of Directors of Law Enforcement Standards and Training (IADLEST).

The format for this course of instruction differs from any published by NHTSA to date, in that there are two course schedules. One schedule is intended for non-radar trained officers and the other for those who have completed the NHTSA radar training course. The latter course is 8 hours classroom and 16 hours hands-on training, while the former is 24 hours classroom and 16 hours of hands-on training.

Many law enforcement agencies are beginning to use more than one type of speed measurement device. We have been advised that training officers in the use of more than one device, using the NHTSA courses, has resulted in a certain amount of duplication. In 1996, NHTSA intends to convert its other speed measurement device training courses to a similar (dual schedule) format. Those courses would include Vascar, Radar, Lidar, and Automated Speed Enforcement Devices (ASED). The concept NHTSA plans to pursue is to develop a "Core Curriculum" for speed enforcement. An officer would take the "Core Curriculum" once, thus eliminating the duplication in existing courses. Once an officer has received the "Core Curriculum" training, it will not be repeated in any subsequent NHTSA speed measurement device training course. It is believed this approach will reduce duplication and the accompanying use of training resources.

This Lidar training course is an interim document to be replaced in 1996 by an abbreviated version that compliments the "Core Curriculum" approach.

NHTSA solicits your comments on both the content of this curriculum and the "Core Curriculum" concept. Please address any comments to:

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Unit 1
Overview and Introduction

This opening unit introduces the topics to be covered during the Basic Training Program in Lidar Speed Measurement. The introduction describes the course's overall goal and lists specific training objectives. It also outlines the contents of subsequent chapters and indicates how they relate to the course's goal. After carefully reviewing this first unit, the reader should be able to:

- **Describe The Course's Objectives.**
- **Describe The Course's Technical Scope and Contents.**

This is the principal study guide and reference source for the Basic Training Program in Lidar Speed Measurement. The information will be expanded and supplemented by your instructor's presentations as well as classroom discussions, sample exercises, and hands-on practice sessions. Included with each unit are study topics, consisting of sample problems and questions about the unit's content and suggestions for reviewing the material covered. Your knowledge of the material and achievement of the unit's training objectives can be tested through the study topics.

This Trainee Instructional Manual is a basic reference, but it is not a complete text for the course. Some of the essential information for this training comes from State and local laws and your enforcement agencies. This "local" information includes statutes and regulations concerning speed violations, policies and procedures affecting enforcement, and the specific role of Lidar devices in enforcement. Such information will be provided through lectures, handouts, and additional suggested reference sources.

It is expected that this Manual will be useful in three different ways. First, before the course is conducted, it will allow a preview of the contents, structure, and sequence of units. This should make it easier to follow the presentations and discussions and provide a solid preparation for a good learning experience. Second, while the course is underway, the Manual will be the principal source of reference material required in class. It is not intended to be read along with the instructor in class, as it will not follow the classroom lectures and presentations. From time to time, though, your instructor may point to specific sections of material contained in the Manual. When the instructor gives a formal test of the knowledge and skill acquired, the Manual plus your class notes will help you prepare for that test. In order to be certified to use Lidar in actual speed enforcement, you will have to have a period of field practice. During that period this Manual can be a useful reference, especially if any operational problems or unusual readings are encountered. Finally, when applying what has been learned and mastered in this course to Lidar speed enforcement, you may encounter instances where your memory will need refreshing. This manual is suited to all of these needs.

Overall Course Goal

The goal of all police work is to protect the lives, property, safety, and the well-being of the public. Traffic law enforcement is no exception. Generally, traffic laws arise from safety-related needs. Preventing crashes requires well-designed roads and vehicles and well-regulated driving behavior. If there were no traffic laws or traffic law enforcement, there would be no regulation of driving behavior. The result would probably be chaos, confusion, more frequent crashes, and many more injuries and deaths. In general, the most important traffic laws are those that regulate the most dangerous driving behaviors. Vehicle speed laws belong to this "most important" class. Research shows that excessive speed is a major contributing factor to motor vehicle crashes. In fact, statistics show that one-third of motor vehicle fatalities, twenty five percent of injury crashes and twelve percent of all police reported crashes are speed related. Further, excessive speed increases the severity of the crashes that do occur: A high-speed crash is much more likely to produce death or serious injury than a low-speed crash. Research also shows that vehicle speeds can be reduced through effective enforcement and that thousands of American lives can be saved each year.

Where does Lidar fit into all this?

Lidar is an important and effective means of accurately establishing vehicle speed. It is not the only means available, and it may not be the best means in certain cases, but it has numerous advantages that make it an extremely useful tool in speed enforcement. Lidar has the potential to make a major contribution to our speed enforcement capability. Lidar was not designed to replace RADAR or other speed measuring systems, but it does add new capabilities for speed enforcement.

The National Highway Traffic Safety Administration (NHTSA) believes that police traffic Lidar is an effective enforcement tool. Police traffic Lidar provides a means of increasing enforcement effectiveness and permits police administrators to make better use of scarce personnel and other resources.

The overall goal of this training program is to improve the effectiveness of speed enforcement through the proper and efficient use of police traffic Lidar speed measurement instruments. It is hoped that every officer who completes this course will become a better enforcer of the traffic laws governing vehicle speed. That is, the officer will detect more speed violations, apprehend more violators, secure more convictions and prevent more motor vehicle crashes.

Specific Training Objectives
This course is designed to help you, the police officer, become a more effective speed enforcer. The knowledge and skills needed to accomplish this relate to proper Lidar speed measurement and carry over into successful speed enforcement in general.
By the time this course is completed, you should be able to:

(1) Describe the association between excessive speed and crashes, deaths, and injuries as well as the highway safety benefits of effective speed control. It has already been stated that excessive speed can cause crashes. Knowing how excessive speed contributes to highway safety problems and how speed enforcement can effectively solve these problems will enable you to better understand your function in the overall traffic safety scheme.

(2) Describe the basic principles of Lidar speed measurement. (This course certainly won't make you an expert in electronics or physics. That kind of expertise is not necessary to operate police traffic Lidar. These basic principles are discussed only to give you an understanding of Lidar's strengths and weaknesses and the kinds of problems that can occur if it is not operated properly. People usually follow prescribed procedures more faithfully if they know why those procedures are needed; this is certainly true of Lidar operators.)

(3) Demonstrate basic skills in testing and operating specific Lidar instrument(s). ("Perfect practice makes perfect." Lidar instruments are fairly simple to operate, but practice is needed before an operator's skills become sharp enough to result in confident Lidar speed readings.)

(4) Identify the specific Lidar instrument(s) used by your agency and describe their major components and functions. (Before a specific Lidar device is used, the operator must understand its specific control functions, characteristics, advantages, and limitations.)

(5) Identify and describe the laws, court rulings, regulations, policies, and procedures affecting Lidar speed measurement and speed enforcement in

general. (Laws cannot be enforced unless they are known. What constitutes a speed violation? What are the elements of the offense? What special rules of evidence apply to the offense? What special rules apply to Lidar evidence? Until these and similar questions can be answered, an officer is not ready to enforce speed laws or use Lidar instruments.)

(6) Demonstrate the ability to prepare and present records and courtroom testimony relating to Lidar speed measurement. (The job does not end when a citation is issued. Evidence must be gathered and presented to support adjudication of the charge.)

At the end of the course, tests will be administered to determine how well the six objectives listed above have been reached. As the course progresses, try to keep them in mind to see how the various topics covered fit into the total learning experience.

Course Content

This course consists of a series of units that address the six objectives just discussed. The topics covered include:

- Speed offenses and speed enforcement. (Speed in relation to highway safety; types and benefits of speed regulation.)
- Basic principles of Lidar speed measurement. (Origin and history of Lidar; target identification considerations; factors affecting Lidar operation.)
- Legal and operational considerations. (Laws, court rulings, policies, etc., affecting Lidar operations; instrument licensing, general operating procedures.)
- Operation of specific Lidar instruments. (Instrument components and their functions; operating procedures; operational demonstrations.)
- Moot Court. (Case preparation, testimony, and cross-examination.)

The outlined content represents a complete course of training in Lidar speed enforcement. Some agencies may decide that some of this content has been adequately covered in other courses and thus may delete or de-emphasize certain items. If used as "refresher" training for more experienced officers, parts also may be deleted. It will be up to the Lidar instructor to advise you of just what local adaptations have been made.

Some Final Words of Introduction

Before the actual training begins, some questions that have been asked by many motorists (as well as police officers and judges) must be considered. Just how good is Lidar? Is it really accurate? Can it be trusted? What are the facts?

Unbiased, scientific tests have shown that the Lidar instruments used in traffic enforcement are reliable tools when properly used by skilled and knowledgeable operators.

Speed enforcement based on Lidar is not difficult to learn, but is complex enough that shortcuts in training can result in less than effective performance. As with all speed measuring devices, the courts demand evidence that the Lidar operator has had sufficient training and experience.

So, finally, just how good is Lidar? It is only as good as you, the operator, make it. If the specific training objectives cited in this course are met, you will be an effective police traffic Lidar operator.

Study Topics:

a. Become familiar with the course objectives.

b. Become familiar with the topics to be covered in later units.

c. Be prepared to answer the following questions:

   1. What is the overall goal of this course?

   2. What are the six specific training objectives of the course?

   3. What are the ultimate purposes of speed enforcement?

   4. If the courts do not expect or require that police officers be experts in Lidar technology, why does this course include training in Lidar's basic scientific principles?

   5. If your proper basic concern is with speed enforcement, why does the course include training in preparing and presenting courtroom testimony?

Unit 2
Speed Offenses and Speed Enforcement

Excessive vehicle speed is a major cause of death and injury on our highways. Thus, the control of excessive speed has long been of paramount interest to traffic law enforcement. Effective regulation of vehicular speed requires first that police officers have a thorough knowledge of the various types of speed laws, as well as where and when they apply; next, that the officers enforce these statutes.

This unit will discuss the problem in general and the existing laws created to deal with that problem. By the completion of the unit, you are expected to be able to:

- Describe the association between speed offenses and motor vehicle crashes and injuries.

- Describe the major types of speed regulations, including their origin, development, and scope.

Speed in Society

Since the earliest days of the automobile, speed has been its most controversial feature. Historically, manufacturers have had little trouble in finding a ready market for fast cars. Concern over the public's fascination with speed was voiced by the Supreme Court of Pennsylvania as early as 1906. In affirming a conviction under a city ordinance for speeding over 7 mph, the Court said:

"It is only necessary to resort to the most cursory observation to find the evidence that many drivers of automobiles in their desire to put their novel and rapid machines to a test of their capacity, drive such vehicles through the streets with a reckless disregard of the rights of others."

Brazier v. City of Philadelphia, 215 Pa. 297, 64 A 508, 510 (1906)

This preoccupation with speed seems to be even more prevalent today, with our highly-mechanized society. People rush to work and rush to play. The automobile provides the means to maintain this harried existence. For some, it also serves as a means to relieve the tensions brought about by living at so rapid

a pace. These individuals turn their automobiles into tools of aggression. This is not to say that most drivers are obsessed with speed.
It is important, however, not to lose sight of the dangers inherent in high speeds. High speeds affect all three elements of driving:

a. The OPERATOR-Increased speeds tax the driver's basic capabilities, such as reaction time.

b. The VEHICLE-Increased speeds impact on vehicle dynamics.

c. The ROADWAY-Increased speeds increase the potential hazards of any deficiencies in the road surface (potholes, construction, etc.) or situational conditions resulting from weather (ice, snow, rain).

High speed interacting with one or more of these elements can result in a crash. To grasp the dramatic impact excessive speed can have, examine the simple task of stopping a vehicle. This task incorporates the three elements previously mentioned and is, therefore, greatly affected by increased speeds.

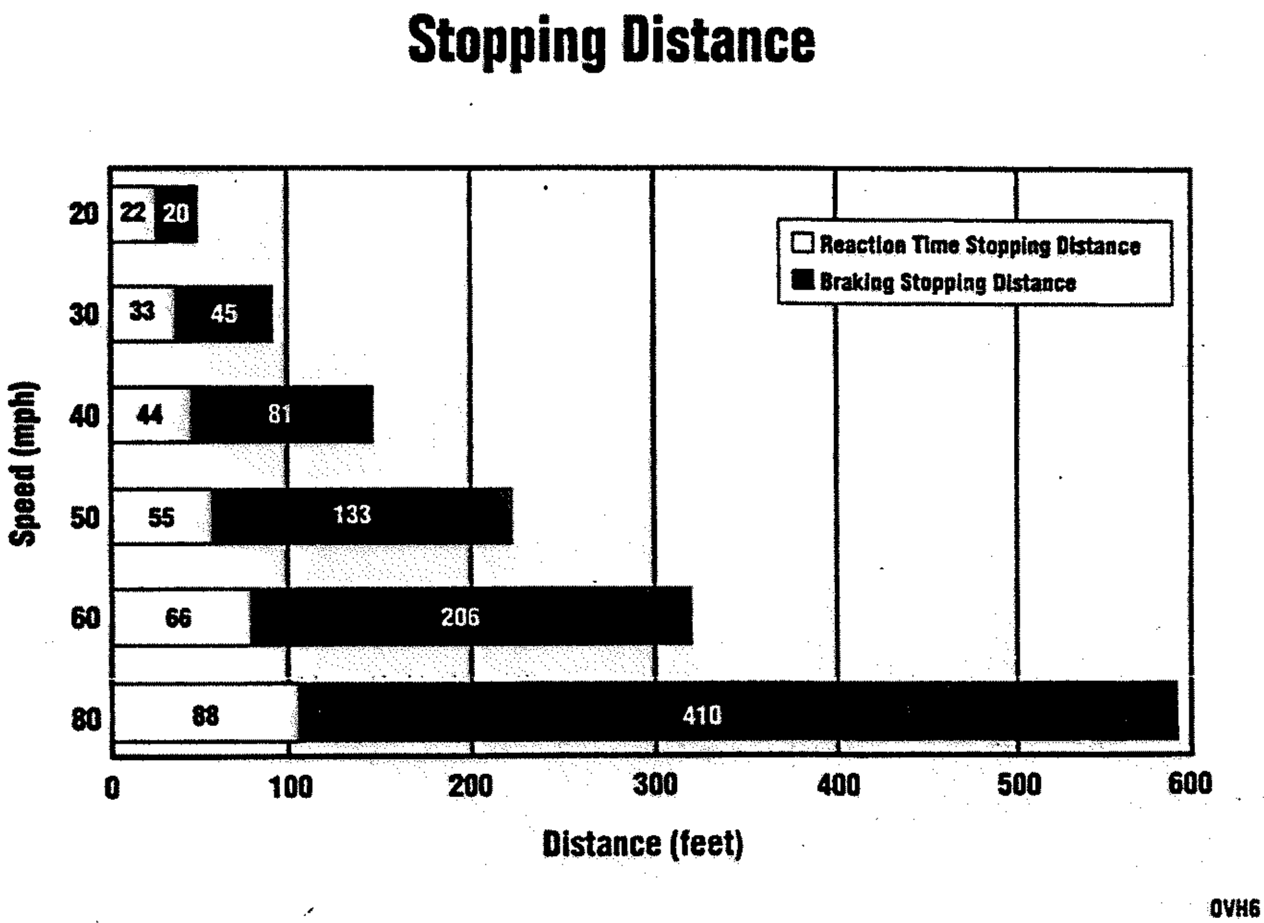
The average person has a reaction time of about 3/4 of a second. Suppose our average motorist is proceeding along a typical road clear of any snow, ice, or other surface problems. Driving at about 20 mph, the motorist notices a hazard ahead and reacts normally. At 20 mph, the car moves 22 feet during this 3/4 of a second. Assuming that the automobile is in proper working order, an additional 20 feet of braking distance is required to bring the car to a complete stop. In total, it has taken the car 42 feet to stop.

Suppose the driver was proceeding at 40 mph. Reacting to a hazard within the same reaction time span, the car will have traveled 44 feet before the driver begins to brake. However, the braking distance is now 81 feet. The braking distance at 40 mph is not twice the distance required at 20 mph, but four times the distance. Now a total of 125 feet is required to bring the vehicle to a halt.

Similarly, the braking distance at 80 mph would not be four times the distance required at 20 mph, but more than 20 times the distance-410 feet. The chart on the following page graphically illustrates the distance needed to stop a vehicle at speeds from 20 to 80 mph.

Remember, this example was based on an average driver with average reaction time, driving a car in good working order, under good road conditions. As speeds increase, a driver maintains less and less real control over the vehicle. Increased speeds tax the effectiveness of the driver's reaction time and the vehicle's stopping capabilities. Additionally, if there had been any deficiencies in our hypothetical driver's reaction time, increased speed would have magnified those deficiencies. Technical advances can increase a cars capabilities or improve the design of roadways to allow for greater and greater speeds. It is much more difficult to "redesign" or improve a driver's capabilities.

Chart 1. Distance Required To Bring A Car To A Complete Stop.



History of Speed Regulation

Various types of legislation to control speed have been introduced throughout our country's history. The primary purpose of this speed regulation has been to make traffic movement more efficient with minimum danger to people and property.

According to Joseph Nathan's "Famous Firsts", the first traffic law in America was passed on June 12, 1652, by New Amsterdam (now New York). It prohibited the riding or driving of horses at a gallop within city limits. Hartford, Connecticut, lays claim to the distinction of having the first automobile speed regulation. This law was enacted in 1901 and limited automobile speeds to 12 mph in the country and 8 mph within city limits.

As the number of automobiles increased, so did the number of laws governing their use. This volume of statutes and ordinances was based, in part, on the assumption that no one should drive a vehicle at a speed greater than is reasonable and prudent under existing conditions. This assumption became known as the "basic speed law."

Enforcing the basic speed law involves procedures different from enforcing speed limits. Under the basic speed law, it must be shown that the violators speed was unreasonable or imprudent given the existing conditions. This is not easy, since any basic speed law includes such ambiguous terms as:

"Reasonable" - - What is "reasonable"?

"Prudent"- -Just what is a "prudent" speed?

"Under existing conditions" -- This term can refer to the condition of the road (whether there are wet or slippery conditions), the condition of the vehicle (whether it is in proper working order), or the condition of the driver (is the person fatigued, intoxicated, etc.?).

Early efforts to enforce this somewhat ambiguous law resulted in some confusion. These enforcement efforts caused two major schools of thought regarding speed enforcement to emerge: those advocating "prima facie" speed limits and those advocating "absolute" speed limits.

Loosely translated, "prima facie" means "at first glance," or "in the absence of further proof." Prima facie speed limits are those stated as a specific rate and posted on the highway, e.g., "Speed Limit 35 mph." However, the basic speed law is the one that has to be enforced and adjudicated. In other words, a speed limit is posted to tell the motorist what is considered a reasonable speed for that area. If a motorist exceeds this speed, the motorist is said to have violated the basic speed law "prima facie."

However, speed in excess of the prima facie limit is only an indication that the speed was unreasonable and imprudent. The accused is entitled to produce evidence in court to show that the speed was reasonable and prudent for the conditions and circumstances at the time in question. A court or jury provides the final decision.

Proponents of this type of law insist that it permits greater flexibility in practice. Not every speed exceeding the stated limits should be considered dangerous. Prima facie limits are not arbitrary and it is contended that most drivers use good judgement and adjust their speed according to the conditions encountered.

"Absolute" speed limits are based on laws that simply prohibit driving faster than a specified speed, no matter what "the existing conditions." This school of thought insists that the basic speed law alone leaves too much room for individual interpretation by motorists-many of whom aren't reliable enough to make correct decisions as to reasonable speeds. It is also maintained that prima facie limits are practically unenforceable, since questions arise in almost every case as to the rate of speed in relation to environmental conditions and what a reasonable speed really is for those conditions. Driving in excess of that absolute limit, regardless of conditions, is a violation. The only proof required is that the motorist exceeded the limit; circumstances and conditions have no bearing on the driver's guilt or innocence.

Speed limits can include both maximum and minimum speed restrictions. Different limits can be set for different conditions, such as:

Time Of Day -- Speeds are sometimes lowered during night or rush hours;

Type Of Roadway -- Highway or urban routes can have different limits than roads in residential areas; and

Type Of Vehicle Or Equipment -- Lower maximums are often set for buses or trucks.

In the early versions of the Uniform Vehicle Code, prima facie limits were recommended, and a majority of States adopted prima facie speed provisions. Meanwhile, the absolute type of law fell into disfavor. In the 1950's more and more States began to adopt absolute limits and abandon the prima facie approach. In fact, the 1956 Uniform Vehicle Code was revised to provide absolute maximum limits and all mention of prima facie was eliminated. Current systems of speed control acknowledge that the speed control system must permit motorists to reach their destinations as rapidly as possible while giving all due consideration to safety, reason, and prudence. Rapid movement of vehicular traffic is essential to efficient highway transportation.

Elements of the Offense

Successful enforcement of speed regulations - whether prima facie limit, basic speed limit, or absolute speed limit - involves more than simply detecting and apprehending violators. Speeding, just as any other offense, can only be successfully prosecuted when certain specific elements of the offense stipulated in each statute are established. The elements of the speeding offense are driver identification, location, speed, and conditions. These elements are specified in general in Table 1. It should be noted that the elements of the different types of regulations are essentially the same, except for "speed," which is defined differently under each type of law. The "location" element in some jurisdictions may include only public highways and roads and in others, parking lots, public driveways, and private roads.

Table 1. Elements of the Speeding Offense

ELEMENTS	ABSOLUTE SPEED LAW	BASIC SPEED LAW	PRIMA FACIE
Driver	Accused must be shown to have been the driver at time of the infraction.	(Same)	(Same)
Location	Any place to which the public has right of access for vehicle use.	(Same)	(Same)
Speed excess of limit	In excess of specified limit. and thus presumed unreasonable or imprudent	Unreasonable or imprudent.	In posted
Conditions	(Not applicable)	Having regard to actual and potential hazards.	Same as Basic

Driver Identification

There are two aspects to driver identification. First, the officer must be able to quickly identify the driver of the vehicle at the time of the initial stop and second, identify the same driver in court at a later time.

After making the initial stop, the officer should make an immediate visual identification of the driver. Other vehicle occupants may attempt to change places with the driver in an effort to confuse the investigation. An alert officer can counter these activities by initially noting driver characteristics such as clothing colors, hats, beards, or other distinguishing characteristics that can be observed at a quick glance. When the officer has completed this first identification of the driver, more specific details that will aid the officer in identifying the suspect in court.

Location

Establishing where the defendant's vehicle was being driven when the infraction occurred is usually not difficult. The officer's testimony that the violation was observed to have taken place on a certain street or highway is sufficient. If there is doubt as to whether the location of a particular roadway is considered public or private, look it up under State statutes or check with a supervisor. If the offense occurred off-highway and is included under your statute, the location can be defined by reference to permanent landmarks.

Speed

Establishing a defendant's speed has differing degrees of importance depending on which type of speed law covers the location of the infraction.

In the case of the basic speed law, the measurement of speed alone will not establish the element of "speed." Remember that the basic speed law states that it shall be unlawful to operate a motor vehicle at an unreasonable or imprudent speed. There are no clear definitions of just what an "unreasonable" speed is, so a measurement of speed is useless without some indication that the speed was excessive.

Prima facie limits suggest what speeds may be presumed to be excessive. The courts will ultimately decide whether a particular speed was unreasonable or imprudent. It is incumbent upon the officer to produce more detailed information to show the courts that the defendant's speed was excessive.

Conditions

In establishing that a defendant's speed was unreasonable or imprudent, the officer must gather information to show it was so in light of existing conditions.

Such conditions include:

1. **WEATHER** -- rain, snow, sleet;

2. **ROADWAY CHARACTERISTICS** -- traffic volume, road surface conditions; and,

3. **THE VEHICLE** -- brakes, tires, or such vision obstructors as a dirty windshield.

Obviously, this type of information does not have to be established in cases involving absolute limits.

Speed Limit Enforcement

Perhaps the most compelling and important reason for stressing enforcement of speed limits is simply that a very substantial number of fatal crashes occur as a result of excessive speed in all speed zones whether fast or slow.

Study Topics:

a. Review the statute(s) governing vehicle speed along a typical patrol route. Which statute(s) governs speed there?

b. Be prepared to answer the following questions:

    1. Distinguish between prima facie speed limits, the basic speed law, and absolute speed laws.

    2. What are the elements of a speeding offense?

    3. What would be an appropriate response to this statement: "Local speed limits are so low that enforcing them isn't really worthwhile."

Unit 3
Scientific Principles of Lidar Speed Measurement

A. Lidar.

The term Lidar is an acronym that stands for "Light Detection and Ranging." Lidar instruments are designed to measure a target vehicle's speed using a form of energy called laser, an electromagnetic energy exhibiting many of the same properties as sound, radio and other microwave energies. The light energy emitted by a Lidar instrument is no different from other light sources. The Lidar does differ in it's method of generating the light energy and it's resulting higher frequency.

The term Lidar is used when referring to speed measuring instruments that employ laser technology for down-the-road speed measurements. Lidar is currently designed for stationary mode operations only.

B. Laser Energy.

In its simplest form, laser energy is energy generated by sandwiching a piece of active material, known as the lasing medium, between two mirrors. These mirrors and the lasing medium form what is called an optical resonator. The atoms of the lasing medium are put into an excited state by an external energy source (the atoms store some of that energy). These excited atoms can then be stimulated to release their stored energy as light energy when another light source interacts with the atoms. This results in an amplification of the incoming light source. By positioning the two mirrors of the optical resonator exactly the right distance apart, a standing wave is formed by only those waves bouncing between the mirrors and having the proper wavelength. Under these conditions, the light waves emitted by the atoms of the lasing medium are aligned in direction and tuned in wavelength (frequency) to increase the strength of the standing wave. One of the mirrors is designed to allow some of this amplified light to "escape" and pass from the optical resonator as a laser beam.

Lasers can be produced from many different materials (solids, liquids and gases) and the design of the optical resonator and the method of exciting lasing mediums may vary. Whatever form the laser takes, the energy is generated by the same basic principle.

C. How Lidar Works.

Lidar employs a time-of-flight method for taking measurements to determine the target vehicle's speed. This method of measurement may be made at any distance within the operating range of the instrument. When the trigger is pulled, the Lidar transmits dozens of laser light pulses per second. When a pulse is transmitted, the timer is started, then when the reflected pulse from the target vehicle is received, the timer is stopped. By comparing the *elapsed time* between the transmission and reception of the laser pulse with the speed of light, the instrument can calculate the *range* to the target vehicle. After making a specific number of these successive range measurements, the data is mathematically analyzed by the processing algorithm. The calculated target vehicle speed is therefore determined from a group of time and range measurements.

To aid the operator with target vehicle identification, if the range to the target vehicle is increasing with time (the target vehicle is moving away from the instrument) the speed reading is designated as a negative value. If the range to the target vehicle is decreasing with time (the target is moving toward the instrument), the speed is designated as a positive value.

Although Lidar instruments employ a variation to the long accepted time/distance method for speed measuring, it does not depend upon specific reference points for obtaining speed measurements. This process employed by the Lidar instrument is dynamic and occurs without the instrument operator having to identify specific reference points along the target vehicle's path-of-travel.

D. Characteristics of the Lidar Signal.

The Lidar signal possess the same three distinguishable characteristics as other forms of electromagnetic wave energy; signal speed, wavelength and frequency.